ELECTROLYSIS OF CONCRETE

THE following observations on this subject are taken from Technologic Paper No. 18 issued by the United States Bureau of Standards. The bureau conducted a great many long time tests of the effect of electric current on concrete reinforced with steel.

They show that with reinforcing iron anode at very low current densities, rusting of iron and cracking of concrete eventually occur, although the damage may not be evident until a lapse of from four to eight years. The cathode effects noted in former tests showed no progress. For the benefit of engineers who may have forgotten some of their knowledge of electricity it may be stated that when the current of electricity flows from the iron to the concrete the iron is anode, and when the current flows from the concrete to the iron, the iron is cathode. The type of specimen and the method of making connections is illustrated in Figs. 1 and 2.

Fig. 3 illustrates the effect of a high voltage with the iron as anode. Fig. 4 illustrates the softening of the concrete near the cathode. By trying specimens of concrete from which the sodium and potassium salts were removed by electrolysis, it was proven that the disintegration of the mortar at the cathode is due to an accumulation there of sodium and potassium by the current and there appears to be a consequent liberation of them of the silicates and aluminates of the set cement with a formation of soluble products. It was obvious that this action would continue until all of the sodium and potassium in the path of the current had been drawn to the cathode. On the other hand, cement free from any appreciable quantities of sodium and potassium would not show the disintegration at the cathode.

The cause of the cracking of concrete with the iron anode was investigated thoroughly. Yielding cylinders used instead of solid steel or iron, developed no cracks in the concrete, and proved conclusively that an interior pressure was developed. The physicists even went so far as to measure these pressures.

Incidentally a method of cleaning iron from rust was developed. Attempts towards reducing the efficiency of corrosion by chemical means met with very indifferent success. Painting or otherwise treating the iron before embedding it in the concrete has not as yet been tried thoroughly, the tests being held up to await the outcome of some experiments with a large number of preservative paints for iron as preventives of natural and electrolytic corrosion in the presence of air and moisture.

The judicious distribution about a structure of courses of masonry or concrete of high specific resistance offers large possibilities as a contributory means at least toward minimizing electrolysis in reinforced concrete in those cases where electrolysis might be expected to occur. Investigations

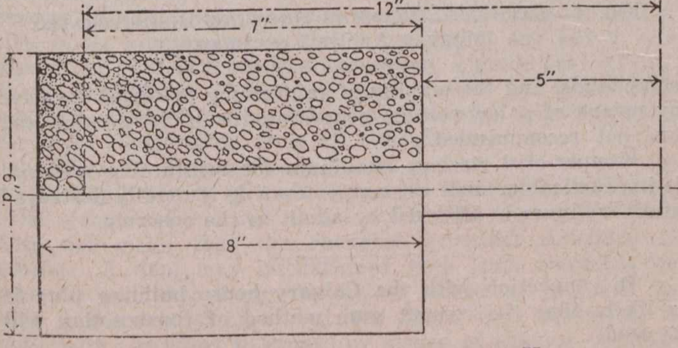

FIG. 1—GENERAL TYPE OF SPECIMENS USED

were accordingly undertaken to ascertain the specific resistance of very wet concrete of different proportions, methods by means of which its specific resistance might be increased, and also the specific resistances of samples of the two commonly used building materials, granite and limestone, in both wet and dry condition. In a search for an effective and durable insulating coating which might be applied to the surface of concrete some tests were made of a number of waterproofing and damp-proofing paints and membranes.

Possibilities of Trouble from Electrolysis in Concrete Structures Under Practical Conditions

The matter has been studied from the practical standpoint also, in order to determine, as far as possible, to what extent the conditions under which concrete can be injured in the laboratory may be expected to obtain in practice.

A careful study of the data shows conclusively that while there are conditions under which reinforced concrete may be seriously injured, such conditions are nevertheless exceptional rather than the rule. These exceptional condi-

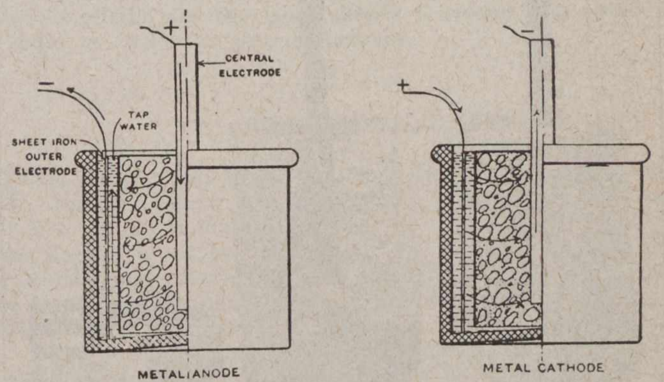

FIG. 2—METHOD OF MAKING CONNECTIONS TO SPECIMENS

tions occur, however, with sufficient frequency to make the problem one of great importance, and fortunately most of these conditions are amenable to control. It has been seen that the most important essentials to the injury of concrete by electrolysis are moisture and a difference of potential between electrodes in contact with the mass of the concrete. At first thought it might appear that these two conditions are almost omnipresent, since perfectly dry concrete, especially below grade, is seldom if ever found; while as every electrical engineer knows, there are few places in our cities at the present time where appreciable differences of potenial can not be found between any two points more than a few yards apart. The statement in regard to the rarity of dry concrete is made advisedly, since only the most minute quantities of moisture are necessary in order to impart to concrete a considerable conductivity. On the other hand, the concrete has to be made very wet in order to impart to it a maximum of conductivity, and any reduction of the moisture content below the saturation point causes an increase in its resistance and a consequent decrease in the current which will flow through the concrete under a given potential gradient. The condition mentioned above, that the electric current must flow between electrodes in contact with the concrete, should be emphasized. The conduction being electrolytic, the reactions taken place only at the electrodes, and in the absence of such electrodes no reactions occur within the concrete.

Sources of Stray Currents

If there be electrodes embedded within the concrete, as in the case of reinforced concrete structures, the electrode effects may be expected provided the voltage is sufficient. The sources of potential differences in concrete structures may be classed under two heads, (1) those due to direct contact between the conductors of lighting or power circuits, and some part of the building and (2) those which have their origin in stray currents from railways or other grounded power lines. The former may happen in any building containing electric wires, through defective insulation. Ultimately, of course, any current that leaks off from the wire would pass out into the earth through the footings and foundations and through pipe systems entering the building. If the current be reversed, flowing to the building from outside, there would in time be some softening of the concrete in a thin layer under and around the steel structure terminating in the footing, but this would be under